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The Vancouver Island Seismic Project: a co-CRUST onshore–offshore study of a convergent margin

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Abstract: The seismic structure of the British Columbia continental margin has been investigated using four reversed refraction profiles. The profile across strike extended 350 km from the volcanic arc on the continent to the deep ocean of the Juan de Fuca Plate; the three profiles along strike were located on Vancouver Island, on the continental shelf, and in the deep ocean on the Juan de Fuca Plate. Interpretation of the profile along Vancouver Island yields a well constrained model for the upper crust with velocity increasing from ~5.3 km/s at the surface to ~6.4 km/s at 2 km depth to ~6.75 km/s at 15.5 km depth where the velocity increases sharply to ~7 km/s. The velocity structure of the deep crust and the crustal thickness are poorly constrained. Four possible velocity functions, based on ambiguous first arrivals and (or) secondary phases interpreted as Moho reflections, are presented. The preferred one includes a deep crustal low velocity zone with a crustal thickness of 37 km; models with a constant 7.1 km/s deep crust require thicknesses of 52 km. Preliminary results from the profile across strike show the dip of the basement towards the continent steepens from approximately 1.4° immediately west of the continental rise to ~4° beneath the rise. Sediment velocities increase as the sedimentary layer thickens towards the shelf. The Moho, with velocity near 8 km/s, appears to dip at similar angles in this region; the dip is ~6° from the edge of the shelf to the central portion of Vancouver Island; here there is an abrupt thickening of the continental crust by about 10 km with a flat-lying Moho to the east. This suggests a contact between subducting oceanic Moho and continental Moho. A small positive velocity gradient is required in the mantle.

Two short reflection lines, one using explosives and the other a large air gun fired in an inlet, were recorded on a land-based multichannel reflection system. These were run to test the feasibility of obtaining coherent reflections to upper mantle depths in this complex geological environment, and of acquiring deep reflection data in coastal areas with an air-gun source. The preliminary explosion section showed reflections near 4.4 and 6.8 s. The depths of these reflections correspond closely to the 15.5 km crustal refractor and the top of the subducting oceanic lithosphere, respectively. Dip on the deeper reflector is close to that estimated from the refraction profile. Without stacking or velocity filtering, the air-gun recordings on a line adjacent to the explosion profile show arrivals of energy at similar times.